

Original Article

THE INFLUENCE OF CEREBRAL INFARCT LOCATION AND VOLUME ON MOTOR AND FUNCTIONAL RECOVERY AFTER STROKE: A NARRATIVE REVIEW

Sivakumar. R ^{*1}, Meenakshisundaram. U ², Shankar. V ³, Arun Maiya ⁴, Rajeswaran. R ⁵.

^{*1} Additional Professor in Physiotherapy, Sri Ramachandra University, Porur, Chennai 116. India.

^{2,3} Professor in Neurology, Sri Ramachandra University, Porur, Chennai 116. India.

⁴ Professor in Physiotherapy, Manipal University, Manipal 576104, India.

⁵ Professor in Radiology, Sri Ramachandra University, Porur, Chennai 116. India.

ABSTRACT

Introduction: The knowledge on effect of location of infarct and volume of infarct on motor and functional outcomes is ambiguous due to variations in methodology and outcome measures used. This narrative review is aimed to summaries the studies ron infarct location and volume related to motor and functional outcome, for a better understanding of the conclusions and limitation of the studies.

Methodology: Literature search was done with key words of location of infarcts, size of infarct, motor recovery and functional recovery with Boolean term AND. Studies using outcome measures of multiple domain was not considered for inclusion.

Results: 13 studies were identified in an extensive search without a time limit. Studies were categorized under location and volume with motor and functional recovery as variables. Majority of studies were done in isolation to any two variables, location outnumbered volume. The relationship with location and motor outcome was inconclusive, though two studies concluded that cortical infarcts had better scores than sub cortical. Volume was moderately associated with motor and functional recovery. Majority of the studies concluded a relationship between location and functional outcome, however the results are variable.

Conclusion: Only few studies have analyzed the impact of infarct in different location and results were inconclusive. Outcome measures were summative in nature, not reflecting recovery in upper and lower extremities in isolation. The amount of recovery is analysed with initial deficits. We suggest more studies are required in this area to provide clarity.

KEY WORDS: Rehabilitation, Motor Recovery, Functional Recovery.

Address for correspondence: Sivakumar. R, Additional Professor in Physiotherapy, Sri Ramachandra University, Porur, Chennai 600116, Tami Nadu, India. **E-Mail:** rsivkumar@gmail.com

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INTRODUCTION

Predicting recovery after stroke is one of the areas of research in neurology and neuro-rehabilitation. Studies have explored different patient related factors like age, gender, type of lesion, size of lesion, site of lesion in relation to motor and functional recovery. Functional recovery is

widely studied compared to motor recovery. The studies have used different outcome measures, focused on different patient attributes [1,2]. Difference in the methodology and outcome measures limits generalization of results to clinical scenario. Very few systemic reviews are available on motor and functional recovery after stroke in relation to infarct profile. We con-

ducted this narrative review to collate the available resources regarding recovery after stroke in relation to location and volume of infarct. At the end of this review we have attempted to summarize our understanding of results of the studies and possible implications.

METHODOLOGY

Studies related to cerebral ischemic stroke were identified. Search was made with key words: "motor recovery AND stroke", "functional recovery AND stroke", "factors affecting recovery AND stroke", "size of infarct AND recovery", "location of infarct AND recovery". Studies were identified with Pubmed, Google scholar, Cochra-

ne reviews, Cinhal. Cross references from each study identified for analysis. Studies which used outcome measures specific to motor or functional domains were included for review. Those studies which used measures with multiple domains like motor, sensory, cognitive were not considered for the review.

RESULTS

We grouped the studies under four categories: 1. Studies related to infarct location and motor outcome, 2. Studies related to infarct size and motor outcome, 3. Studies related to infarct location and functional outcome and 4. Studies related to infarct size and functional outcome.

Author	Infarct location/volume	Outcome measure	Number of patients and Post stroke period of observations	Results
Chen et al. 2000	Location and volume	Motor score: Brunnstrom stages Functional score: Functional Independence measure	55 patients. Around 1 month post stroke and 6 month post stroke	Study was concluded that lesions larger than delimiting size regardless of location had poor motor and functional outcome. Study was concluded that lesions larger than delimiting size regardless of location had poor motor and functional outcome. Size alone was not a predictor.
Pantano et al. 1996	Location and volume	Motor score: Adam's scale	37 patients. Not fixed. Initial assessment and three months later. Initial assessment(2 to 7 months post stroke)	Infarct location, side and size did not correlate with severity or evolution of motor deficit. Parietal lobe lesion had severe motor deficit than other cortical lesions. No difference was identified between cortical and subcortical infarcts.
Puig et al. 2011	Location and volume	Motor score: motor components of NIHSS	60 patients. 3rd post stroke day, 30th post stroke day and 90th post stroke day.	Infarct volume was not a predictor of motor outcome at 90th day. Location of infarct in posterior limb of internal capsule was the best predictor for motor deficit at day 30.
Ganesan et al. 1999	Location and volume	Motor score and functional score: customized unpublished scale, motor impairment was graded on a four point scale	38 patients. Retrospective data collection, point of measurement was not specified.	Location as cortical or subcortical did not affect the outcome. Volume did not influence the motor outcome. However infarcts occupying more than 10% of intracranial volume had poor recovery
Shelton & Reding 2001	Location	Motor score: FMA (Upper Limb)	41 patients. Around 2 months post stroke	Cortical infarct infarcts recovered better than subcortical or mixed cortical and subcortical infarcts.
Fries et al. 1993	Location (Internal Capsule)	Motor score: Rivermead stroke assessment	23 patients. Immediately after stroke and 5months post stroke to 96 months post stroke	Lesions restricted to basal ganglia did not result in motor impairments. Lesions isolated to anterior or posterior limb of internal capsule recovered well though initial motor deficit was severe. Infarct covering posterior limb of internal capsule and thalamus had less satisfactory recovery.
Miyai et al. 1999	Location(middle cerebral artery infarcts)	Motor score: motor sets of stroke impairment scale	31 patients. Around 4 months initial assessment and around 7 months followup	Lesions in premotor cortex affected proximal motor control in lower limb
Wenzelburger et al. 2005	Location (Internal Capsule)	Motor score: RMA (Hand)	18 patients. Chronic stroke patients mean 2.5 years	Lesions in posterior limb of internal capsule affected the hand function recovery
Beloosesky et al. 1995	Location and Volume	Functional score: modified Rankin scale	56 patients. Not specified	Sub cortical infarcts scored better than cortical infarcts. Volume of cortical infarcts had direct relationship with functional outcome.
Dromerick & Reding 1995	Location	Functional score: Barthel index	41 patients. Retrospective data; no time period specified	Location not related to functional outcome
Paithankar & Dabhi 2003	Volume	Functional score: modified Rankin scale	72 patients. Point of evaluation 3rd month post stroke	Size of infarct had influence on outcome.
Saver et al. 1999	Volume	Functional score: Barthel index	132 patients. 3 months post stroke	Volume had moderate correlation with functional outcome
Schiemanck et al. 2006	Volume	Functional score: Barthel index	NA – Review article	Volume had moderate correlation with functional outcome

Location and motor: We found 8 studies matching our criteria (Table 1). Two studies were specific with location around internal capsule region; other studies included both cortical and subcortical areas for analysis. Except a study by Ganesan et al. (1999) all other studies have used a known outcome measure for motor domain [3]. However the measures were different among the studies. Post stroke time of evaluation was not similar among the study. Retrospective data collection was identified in two studies [3,4]. All studies gave a composite measure of motor scores including upper and lower limb scores except study by Shelton & Reding (2001) [5], which focused on upper limb motor scores. Shelton & Reding (2001) stated that cortical infarcts had better outcome than subcortical infarcts [5]. However Ganesan et al. (1999) and Pantano et al. (1996) concluded that infarct location did not influence motor scores [3,6]. They did not report variations in outcome between cortical and subcortical infarcts in their study population. Chen et al. (2000) stated that lesion size along with location to be considered for outcome rather than location alone [7]. They concluded that lesion beyond a given size in specific area had poor outcome. Studies which focused on internal capsule area concluded that lesions involving posterior limb of internal capsule had poor outcome [4,8,9]. Fries et al. (1993) have added that involvement of thalamus along with posterior limb of internal capsule resulted in less satisfactory recovery compared to isolated involvement of posterior limb of internal capsule [4]. Wenzelburger et al. (2005) studied hand function, whereas other studies examined upper and lower limb scores together [8].

Size and motor: Three studies had considered infarct size and motor outcome (table 2). Chen et al. (2000) states that size of the lesion had weak or no relationship with motor outcome [7]. Puig et al. (2011) also states absence of statistically significant relationship between size and motor outcome [9]. Ganesan et al. (1999) concluded that infarct more than 10% of intracranial volume was associated with poor outcome [3]. As mentioned earlier studies used different outcome measures.

Location and function: Functional outcomes

were generally studied using Barthel Index and Functional independence measure. We considered four studies for the review. Macciocchi, et al(1998) and Saeki et al(1994) used Barthel Index to measure functional outcome in relation to location of lesion and concluded that location of lesion as a predictor for functional recovery(10,11). Chen et al correlated functional abilities using FIM with brain lesion profile and concluded an existence of a relationship [7]. Another study concluded that gait asymmetry was evident in patients with posterolateral putamen infarct. [12]. However Dromerick & Reding (1995) concluded that location of lesion did not relate to functional outcome [13].

Size and function: Five studies were placed under this category [7,12,14–16]. The outcome measures were different among the studies. Two studies had evaluated out come at three months post stroke and one study had data for first month and six month post stroke. All the studies concluded that volume of infarct had influence on functional outcome.

DISCUSSION

We found divisive conclusions regarding location of infarct and size of infarct in relation to motor outcome, however existence of a relationship between location of infarct and size of infarct with functional outcome was generally accepted. Studies focusing on location of infarct in relation to motor and functional outcome are more than those studied volume of infarct. Outcome measures were different among the studies. Age of the patients were different were different among the studies; one study included pediatric population [3]. The results of the studies especially in motor outcome are elusive due to methodological variations including outcome measures, time of evaluation, categorization of patients based on location and outcome measures, analysis of outcome – amount of recovery or recovery at the point of evaluation and patients studied (acute to chronic). Majority of the studies analysed volume or location, except four studies which included both location and volume of infarct for analysis [3,7,9,16].

Motor outcomes were evaluated with scores

which are summative in nature. Summative score cannot provide details of specific deficit of the patient. Studies included have used Fugl Mayer Assessment (FMA) [5], Adam's scale [6], Motor components of National Institute of Health Stroke Scale (NIHSS) [9], Rivermead stroke assessment [4] and motor sets of stroke impairment scale [17]. Brunnstromme stages was used by one of the study [7] and another used an unpublished measure developed [3]. In general studies have taken scores of both upper and lower limb together for analysis except three studies [4,5,8] which used upper extremity motor scores and hand motor scores in isolation. In a summative score same total score does not assure similar scores in upper and lower extremity components. Hence it may be difficult to conclude on relation between infarct profile with recovery in upper and lower extremity.

The studies grouped patients based on motor scores for analysis, which we felt may not be appropriate when viewed from clinical standpoint. Shelton et al (2001) have used FMA upper limb component to analyse the impact of location of infarct on upper limb motor recovery [5]. They grouped the patient as those with no/minor movement, having synergy and having isolated movements. The cut off scores may not be appropriate as patients may have some isolated movement even before they get full components of synergy as recovery is a continuum in nature. The cut off score will set apart patients with small difference in movement. They have included patients with no movement or minor movement into the study. Initial motor control can determine final outcome. The study did not analyse to show a change in the control from initial evaluation. Hence patients who would have improved minimally to shift between the groups were not reflected explicitly by the results. These points are to be considered when understanding the results of Shelton & Reding (2001) Chen et al. (2000) have used Brunnstromme stages of motor recovery as outcome measure. In this study the scores of upper limb, lower limb, hand and foot were summated to provide an outcome. The cutoff points were used based on the presence of isolated movements. The cutoff point will have larger section of movement possibilities

on either side. Similar to study by Shelton et al, the outcomes were grouped as good and poor recovery, without considering the initial motor scores [5]. This study had included few patients with hemorrhage. As recovery in hemorrhage and infarct can differ(18,19), it may not be appropriate to generalize the result to patients with infarcts.. The other studies including the cortical and subcortical infarcts have used scales which are not tested for their sensitivity to change. Hence the scales ability to reflect the change in the clinical picture becomes unclear. Two other studies have focused on gangliocapsular region, hence they cannot reflect the relation between cortical and subcortical infarcts. Though majority of the studies have agreed on the points like cortical infarcts shows greater recovery, posterior limb of internal capsule infarct is associated with poor recovery, few studies does not support these points [3,6]. In general cortical infarct population was fewer in number in all the study groups, compared to subcortical.

Volume of the infarct was less explored area in association with the location of the infarct. Chen et al states that volume of the infarct alone is moderately associated with the motor outcome [7]. They proposed delimiting size of infarct location to categorise good and poor recovery. The two other studies included in the review concluded that infarct volume was not a predictor of motor recovery.

Functional evaluation was widely done with measures like Barthel index, FIM. It was noted that these measures merely looks at the functional changes, not recognizing the contribution by the paretic side. The functional improvement by compensation from normal side will be influenced by many factors not just infarct location alone. In general studies have concluded that cortical infarcts have greater functional gains than sub cortical infarcts. Size of infarcts was found to have moderate relation with the functional outcome.

This review reveals that though it is believed that cortical infarcts will get a better motor score than subcortical infarcts, variations are possible based on the study population. The studies have given only motor scores at a particular point of

time, it is worth noting that recovery is based also on the initial deficit [1,10], which reflects the potential of the nervous system. However we could not find studies using motor scores comparing the initial and final scores to project the recovery. Studies on volume stating that has a relation with functional outcome have not considered the location of infarcts [12,14].

CONCLUSION

We found that very few studies have focused in the area of infarct profile and motor or functional recovery. Inconsistency in methodology among the studies should be considered while generalizing the outcomes. With the present review we conclude that location and volume both should be considered for predicting recovery, initial deficit should be accounted for quantifying the recovery. As a therapeutic implication the influence of infarct profile on treatment has to be considered in research. However influence of lesion profile is not considered in the inclusion criteria of studies evaluating therapeutic outcomes in stroke population. We felt that influence of lesion profile on therapeutic outcome is not given importance due to dearth of studies in this area. We suggest for studies more studies evaluating the influence of location and size of infarct on motor outcome. Therapeutic studies need to consider infarct/lesion profile in inclusion criteria.

Conflicts of interest: None

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